

this has the constitution corresponding to **FIG. 4(a)**. A more desirable structure is obtained by controlling the composition of the Co alloy magnetic film used as the magnetic domain control film **11**, thereby increasing the saturation magnetic flux density  $B_s$  of the magnetic domain control film **11** more than that of the material used for the free layer **7**, and constituting the thickness of the magnetic domain control film **11** less than that of the free layer **7**. An NiFe thin film is used for the free layer **7** and the saturation magnetic flux density  $B_s$  thereof is 1 T. For example, in a case of a CoCrPt alloy thin film, the saturation magnetic flux density can be increased to about 1.7 T by decreasing Cr and Pt compositions. As a result of an experiment, it has been found that a sufficient bias magnetic field can be obtained even at a thickness 0.75 times the thickness of the free layer **7**. In this structure, compared with the structure shown in **FIG. 1**, the fixed layer ferromagnetic body is not etched in the ion beam etching step and the end is not exposed. Accordingly, less bias magnetic field is applied from the magnetic domain control film **11** to the pinned layer **5** while more bias magnetic field can be applied to the free layer **7**. This is a structure preferable to that in **FIG. 1**.

**[0057]** When the amorphous thin film **9** is formed on the lower surface of the magnetic domain control film underlayer **10**, a gap distance that is the sum of the film thickness of the Cr underlayer **10** and that of the amorphous thin film **9** (S in **FIG. 4**) is formed between the Co alloy magnetic film of the magnetic domain control film **11** and the end of the free layer. Since it is likely that the gap distance weakens the bias magnetic field, it is desirably constituted as small as possible. Therefore, the thickness of the Cr underlayer film **10** and that of the amorphous film are desirably constituted as thin as possible within a range that the magnetic characteristics of the Co alloy magnetic film are satisfactory.

**[0058]** The amorphous thin film **9** has to be selected from metal alloy thin films. As a result of various studies, it has been found that the foregoing object can be satisfied by forming an alloy amorphous thin film using Ni as a mother layer or Co as a mother layer and incorporating an additive element. It has been known that an amorphous film of Cr alloy thin film may sometimes be adopted. A technical subject as to what thin film is to be formed further on the lower surface of the Cr underlayer in order that the Co alloy thin film shows good magnetic characteristics is a technique developed in the course of the seed film formation of a thin film magnetic recording media. According to this, while the seed film constituted below the Cr underlayer should have an amorphous structure and it is considered that the constitution alone is still insufficient and selection of a material and an oxidation process to control the surface energy are also required. It of course depends on the forming condition upon thin film preparation. In the present invention, even when the amorphous film is formed on the face-centered cubic (fcc) thin film constituting the stack of magnetoresistive layers, materials for maintaining the amorphous structure and the manufacturing method have to be selected.

**[0059]** Further, with a view point that the magnetic domain control amorphous film **9** is a portion in which current flows to elevate the temperature, the additive element is preferably selected from high melting metals and the additive element is preferably selected from low resistance metals. Since current flows between the Co thin film of the magnetic domain control film **11** and the stack of magne-

toresistive layers in an actual sensor structure, it is necessary that the electric resistance is as low as possible. Accordingly, the additive element is selected, for example, from P, Cr, Zr, Nb, Hf, In, Mo, Ti, V, Ta, W, Ru, Rh, Pd and Pt, and it is preferred that one or two or more of them are added to Ni or Co to provide a substantially amorphous structure. Preferably, the amorphous alloy has to be a composition of making the magnetic property of the Ni or Co film to that of non-magnetic property as an amorphous alloy.

**[0060]** It is considered that the effect of the element added to the Ni metal or Co metal is estimated that it not only changes the surface energy thereof but also gives a more effect on the formation of an initial growing layer upon crystal growth of the Cr alloy underlayer to change the crystal structure of the Cr underlayer **10** more intensely upon conducting the oxidation process after formation since it provides selectivity for atoms adsorbed on the surface of oxygen. Crystal system thin films of controlling the crystal growing orientation of the Cr alloy polycrystal thin film in the polycrystal thin film system other than the surface oxidizing the amorphous metal surface have not yet been known at present. This is estimated to be attributable to that the face spacing of Cr crystal is smaller than the face spacing of many other crystal materials but it is not certain at present.

**[0061]** **FIG. 6** schematically shows the relationship of crystal orientation faces when the amorphous alloy thin film is newly introduced. Generally, the crystallographic orientation of the Cr alloy thin film underlayer and the Co alloy thin film has an intense correlation with the orientation face relation by the hetero-epitaxy crystal growing mechanism. The Cr alloy film takes a body-centered cubic (BCC) crystal structure and Cr(110) orientation thin film and Cr(100) orientation thin film as the closed packed face have been known. When the Co alloy thin film is formed on the Cr(100) orientation thin film, it is known a case of Co(10.0) Co(00.1) mixed crystal orientation, a case of Co(10.0) Co(00.1) Co(11.0) mixed crystal orientation and Co(00.2) orientation, which change depending on the film forming conditions. It has been known that when the Co alloy thin film is deposited on the Cr(100) orientation thin film, it provides Co(11.0) orientation.

**[0062]** States A2 and A3 in **FIG. 6** show a state of Co(00.1) orientation on the Cr(100) orientation face, in which the C axis of the Co alloy thin film is oriented vertical relative to the film plane. Only the state of State A2 can be attained on the layer of most of face-centered cubic (fcc) system polycrystal thin film of the stack of magnetoresistive layers. State B in **FIG. 6** shows a case of a Co alloy thin film isometrically oriented on the Cr underlayer. State C in **FIG. 6** shows a case in which the Co(11.0) face is oriented to the Cr(100) orientation face in which the C axis of the Co alloy thin film is oriented in parallel relative to the film plane. Orientation of the Cr thin film can be changed as State A3, State B and State C by controlling the material of the amorphous alloy disposed below the Cr underlayer and the degree of oxidation of the surface thereof, and the C axis orientation of the Co alloy thin film can be changed from the direction vertical to the film plane to the direction in parallel thereto irrespective of the underlayer state before formation.

**[0063]** As a result of observing the magnetic operation of the free layer **7** by forming the magnetic domain control film **11** and the free layer **7** substantially at the same height and